SURGICAL TREATMENT OF STRABISMUS*

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CASES of strabismus are usually first seen by the family doctor or pædiatrician and it is important that they should give proper advice to the parents. Some years ago that advice was, "Leave it alone until they are fifteen and they will grow out of it". Now, however, it is generally accepted that treatment of strabismus should be completed before school age so that the child is not handicapped by a physical defect which might affect its whole life. Most authorities are agreed that treatment should begin early and if an operation is necessary it should be done before school age. The chances of cure and good binocular vision are much better if this is done. If treatment is delayed, amblyopia usually develops.

The arguments against early treatment are usually: 1st, fear of an anæsthetic, but this would apply to any surgical procedure; 2nd, if an operation is done early, the eye may turn out later. When tenotomies of the internal rectus were in vogue, this was often the case, but now with improved technique and proper diagnosis, the fear of the eye turning the opposite way has been largely eliminated. Orthoptic training has its place to develop binocular vision and in conjunction with operation, but it is not a cure-all.

The most important step in treatment is the correct diagnosis. Each case must be thoroughly examined several times before a definite opinion can be given as to the underlying cause. It will be found that the condition will vary from day to day and is influenced by the patient's general condition. Fatigue usually makes strabismus more pronounced. This is particularly noticeable in esotropia and hypertropia in children. The parents may notice the eyes turn at home, particularly in the evening, while on repeated visits to the doctor the eyes will be straight.

Spasms of individual muscles vary, particularly those of the inferior oblique and they must be carefully sought for. Babies' eyes often do not coordinate until they are several months old. Crossed eyes should not be neglected after twelve months and treatment should begin as soon as possible after the age of fifteen months. A concerted effort should be made to have the child's eyes straight before school age. Some cases do not develop until the age of two or three years and treatment should be started as soon as it is noticed.

It is my purpose to outline the various tests used in diagnosis in the treatment of strabismus, with special regard to surgical treatment. This paper is based on a series of about 800 cases seen at the Hospital for Sick Children, Toronto, in which some surgical procedure was done in about 25 per cent. Simple tests to determine if the child's eyes are crossed which can be used by a general practitioner or pædiatrician are outlined.

DIAGNOSIS

It is important that one should have a thorough understanding of the various tests used in diagnosis of strabismus. Many failures in treatment are due to the fact that the examiner was unable to determine the underlying cause. The methods used in diagnosis are: (1) corneal reflex test; (2) screen and parallax; (3) Excursion test; (4) convergence near point; (5) prism convergence, and divergence; (6) diplopia plotting; (7) Maddox rod; (8) refraction.

1. *Corneal reflex test.*—The general practitioner or the pædiatrician is often asked, "Doctor, are my baby's eyes straight?" Sometimes it is difficult to determine if strabismus is present. The bridge of the nose of many babies is very wide so that it covers the sclera medial to the cornea giving the appearance of crossed eyes. The corneal reflex test is used to determine if the eyes are straight. The examiner should shine a flashlight into the baby's eyes about fifteen inches from its face and observe the corneal light reflexes in each pupil (see Figs. 1, 2, 3 and 4). A baby will usually look at the light. If the eyes are straight, the reflex will be in the centre of each pupil but if they are crossed it will be in the centre of one pupil and towards the edge of the cornea in the other. In children under a year little more can be done.

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2. *Screen and parallax.*—The screen is the objective and parallax the subjective test. It is taken at thirteen inches and twenty feet. The patient looks at a small light or the head of a white pin thirteen inches from the eye. The examiner covers one eye with a card and moves it quickly from one eye to the other. Watch the eye to be uncovered. If the eyes are normal there is no movement, but if there is a muscle imbalance the eye will swing towards the light as it is uncovered. With esophoria or esotropia the eye swings out and in exophoria or tropia it will swing in. To differentiate a phoria from a tropia cover one eye then uncover it. If the eye swings into line with the other, it is a phoria, if not, a tropia. Do this test in the six cardinal positions which are: (1) up and right; (2) up and left; (3) right; (4) left; (5) down and right; (6) down and left. The amount of deviation can be measured by putting prisms of various strengths in front of the eye until there is no movement. The prisms are square and held in the hand, care being taken to hold them straight and the surface of the prism nearest the eye should be at right angles to the line joining the test object and the eye. The same tests are done at twenty feet and measured.

3. *Excursion test.*—Partially cover one eye with a card and observe that eye while the patient follows the test object with the other eye; repeat the test with the other eye. In this way a spasm or paralysis can be elicited when the object is carried into the field of action of the affected muscle. If there is a nystagmoid movement in any field, suspect a weakness of the muscle acting in that field.

4. *Convergence near point* is the closest distance to the eye at which the patient still has fusion. It is normal at about 60 to 100 mm. from the eye, or 45 to 75 mm. from the bridge of the nose. The test object should be held at some distance from the eyes and slowly brought towards them. Watch for the point at which one eye swings out and note carefully which eye swings first, as that usually indicates which internal muscle is at fault.

5. *Prisms-convergence and divergence.* — A person should be able to overcome a prism base out at 30 to 60 diopters, but will only overcome about four to eight diopters base in. The prism tests, however, are not essential to diagnosis.

6. *Diplopia plotting with the tangent screen.*—This test can be done only if the patient is not suppressing the image in the affected eye. The patient is seated one metre in front of a tangent screen and a red glass held over one eye. The most convenient test object is the light from a May ophthalmoscope with the condensing lens removed. The diplopia is plotted out in the six cardinal positions. If the eyes are normal there should be no separation of the light but when it is carried into the field of action of the affected muscle the red and white lights will separate.

7. *Maddox rod.*—This is a very common test but is of very little use in diagnosing muscle weaknesses. It is helpful in hyperphorias in prescribing glasses. One must remember that the hyperphoria may vary when the patient looks up or down and it should be checked in all fields.

8. *Refraction.*—A thorough refraction under cycloplegic should be done. The foregoing tests should be made with and without glasses.

Six different tests have been outlined to be used in the diagnosis of muscle abnormalities; sometimes only one or two can be used. In the case of small children, the screen and excursion tests are usually all that are necessary to make the proper diagnosis. Children often do not co-operate well enough to measure the deviation with prisms. A convenient method to measure the angle of deviation is to have the child look at a light held thirteen inches from the eyes. The corneal reflex will be in the centre of one pupil and eccentric in the other. Measure in millimetres the distance the reflex lies from the centre of one pupil of the deviating eye. This number multiplied by seven gives a rough approximation of the deviation and is usually about one-half the measurement by prisms. The cornea is approximately 12 mm. across, so that the mid-point is 6 mm. from the periphery. It is easy to divide this into various parts so that if the reflex appears to be about midway between centre and periphery, the squint is about 21 degrees and this is equivalent to about 35 prism degrees.

So much for the methods. How are they interpreted? Three types of strabismus are found: (1) convergent strabismus; (2) divergent strabismus; (3) hypertropia. The commonest condition dealt with is convergent strabismus or esotropia. There are several causes each requiring a separate type of treatment so that it is obvious each case must be thoroughly investigated to determine the under-

lying cause. Only then can proper treatment be applied. The causes are as follows: (*a*) convergence excess; (*b*) divergence weakness; (*c*) hyperphoria; (*d*) paralysis of an external rectus; (*e*) spasm of an internal rectus; (*f*) congenital anomalies.

(*a*) *Convergence excess.* — The commonest cause of convergent strabismus or esotropia is convergence excess accompanying hyperopia. At first the child's eyes turn in only when close work is done; later the eyes turn in more until finally one eye is constantly turned showing that a secondary divergence weakness has developed. The refraction should be done under complete mydriasis and if the child is old enough, the deviations for distance and near can be measured. It will be found that the findings for near will be greater than those for distance. It is important to determine if the deviation is the same in all directions of gaze. The near point of convergence is very close to the nose.

(*b*) *Divergence weakness.*—The tests for near are usually normal but when taken at twenty feet show marked convergence. Care must be taken to determine if the divergence weakness is due to a paralysis of the external rectus. This can be determined by muscle plotting and the excursion test.

(*c*) *Hyperphoria.* — This condition is often overlooked as a cause of convergent stabismus. The primary condition is often a partial paralysis of the superior rectus with a secondary overaction of the inferior oblique of the opposite eye. This is easily brought out by the excursion test when the eyes are brought into the field of action of the affected muscle. A head tilt may be present and the condition is often bilateral.

(*d*) *Paralysis of the external rectus.*—This can be brought out by the screen and parallax, excursion test and diplopia plotting. It is usually secondary to some such disease as, infection of the petrous portion of the temporal bone, syphilis, or following an accident. It is unwise to attempt to do any surgical treatment until one is sure of the cause and no further improvement can be obtained by general treatment.

(*e*) *Spasm of the internal rectus* can be determined by diplopia plotting and the excursion test. It is not common and is usually secondary to a paralysis of either the opposite internal or external rectus of the same eye.

(*f*) *Congenital anomaly.*—Paralysis of any of the eye muscles may be congenital and it is usually easy to determine by the excursion test and diplopia plotting. Occasionally the external rectus is replaced by a fibrous band, giving rise to Duane's retraction syndrome. There is no outward rotation and on adduction the palpebral fissure is narrowed because the globe recedes inwards.

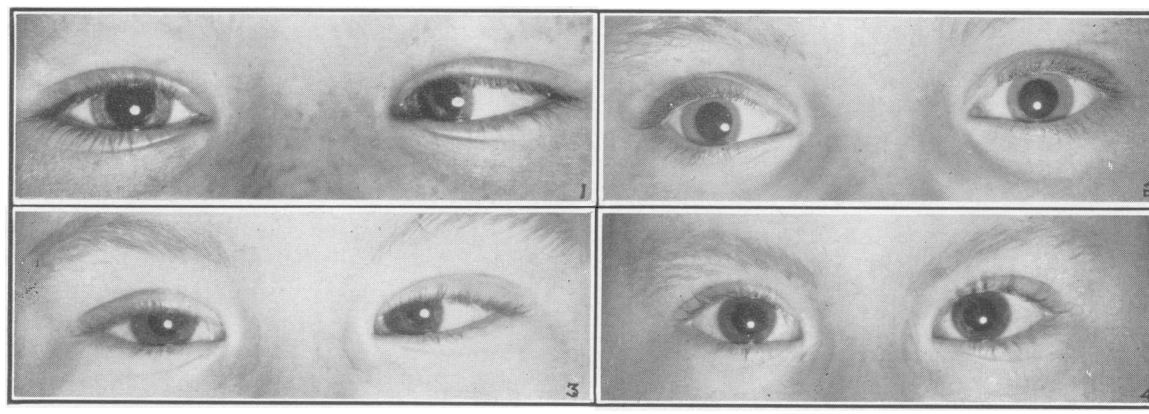

Fig. 1.—Esotropia or left convergent strabismus. Note light reflexes in centre of right pupil and at edge of iris in left eye. **Fig. 2.**—Exotropia or right divergent strabismus. Note light reflexes in centre of left pupil and to the inner side of pupil in the right eye. **Fig. 3.**—Esotropia of left eye. **Fig. 4.**—Same patient as in Fig. 3, three months after recession of left internal rectus muscle and resection of left external rectus muscle. Note light reflexes in same position in both pupils.

2. *Divergent strabismus or exotropia* is much less common than convergent strabismus. It occasionally accompanies myopia but is more often due to convergence weakness or a divergence excess. Occasionally it is secondary to hypertropia.

In convergence weakness the patient is unable to converge and the deviation for near is much greater than for distance. In divergence excess, convergence may be normal but in looking at distant objects the eye will wander out.

3. *Hypertropia.* — This is not common but

should always be looked for. It can usually be brought out by the excursion test and screen and parallax. The hypertropia will be much more marked in the field of action of the affected muscle.

TREATMENT

1. *Convergent strabismus.*—It is important to determine which is the fixing eye. Atropine ointment 1 per cent is put in the child's eyes three times a day for three days to relax the accommodation. Many accommodative cases of convergent strabismus will straighten with atropine and this usually indicates that glasses will hold the eye straight. If glasses are necessary, they may be put on as early as fifteen months and a full correction should be prescribed. Babies will wear them readily.

2. *Divergence weakness.*—This does not respond well to passive treatment and usually requires strengthening of the external recti by operation.

3. *Hypertropia.*—If slight this can be helped by vertical prisms but marked hypertropia usually requires operative interference before a cure is effected. The commonest type is spasm of the inferior oblique secondary to the paralysis

TECHNIQUE OF OPERATION FOR SHORTENING AN OCULAR MUSCLE

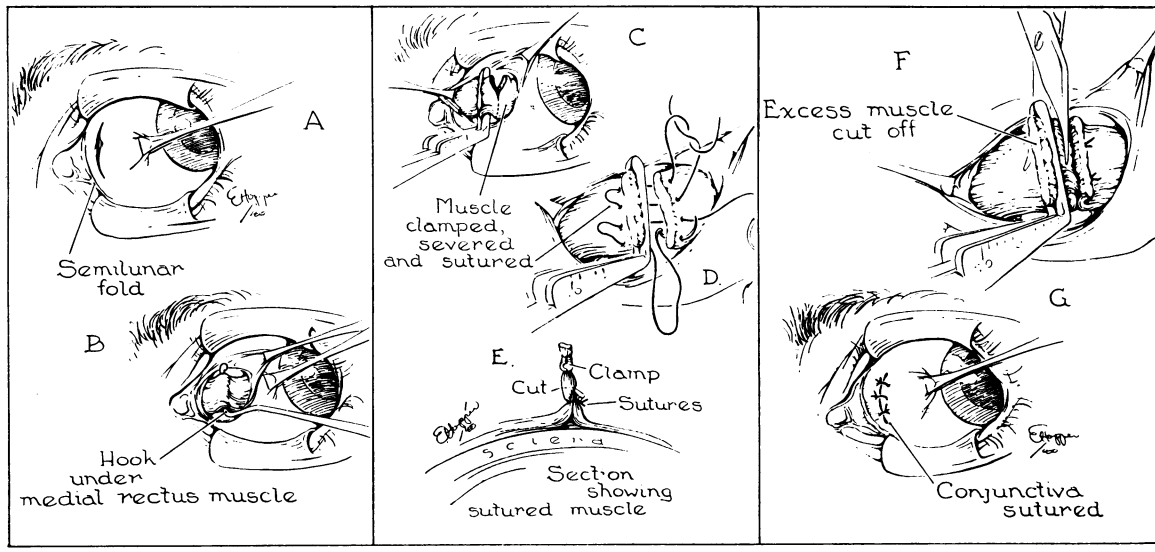

Fig. 5 **Fig. 6** **Fig. 7**

Fig. 5A.—Conjunctiva grasped with fixation forceps. Incision through conjunctiva. **Fig. 5B.**—Rectus muscle picked up by muscle hook. **Fig. 6C.**—Clamp applied and muscle severed from the sclera leaving a good stump. **Fig. 6D.**—Two double arm 000 chromic catgut sutures put through muscle and stump. **Fig. 6E.**—Sutures tied showing how fibres are prevented from slipping. **Fig. 7F.**—Excess muscle cut off. **Fig. 7G.**—Conjunctiva sutured with interrupted sutures.

An effort must be made to make the patient use the turned eye. This can be done several ways: first: putting atropine ointment in the good eye once a day. This should not be continued for more than three weeks. Second: cover the good eye for several hours each day. An occluder on the glass may be sufficient but it is sometimes necessary to put on a firm adhesive bandage. Care must be taken not to carry on the treatment too long at one time or the good eye may become crossed and even amblyopic.

If the eyes still turn in despite treatment then an operation must be considered, and I am of the firm opinion that this should be done before the child enters school, preferably at the age of two or three. If the operation is done early, fusion is accomplished much more readily. The psychological aspect is very important and should not be overlooked. Cross-eyed children have to suffer the jeers of their playmates and are sometimes considered below par mentally.

OPERATIONS

The most important step in any operative procedure is pre-operative diagnosis and determination of the underlying cause. Unless that is accurately determined before hand the operation has only a slight chance of success. As most cases of convergent strabismus are due to convergence excess, weakening the internal recti of the superior rectus of the opposite eye. Weakening of the inferior oblique by cutting out a piece of the muscle usually gives excellent results.

gives good results but it is sometimes necessary to strengthen the external recti because of secondary divergence weakness.

(*a*) *Weakening operations.*—Tenotomy of the internal rectus is very uncertain and has been pretty well discarded. Procedures have been outlined for weakening the internal rectus by placing the insertion farther back. They are all based on the same principle of suturing the muscle to the sclera about four or five millimetres behind the original insertion. Jamieson's[1] recession is a very excellent operation and gives good results if properly done.

(*b*) *Strengthening operations.*—Many operative procedures have been devised for strengthening a muscle. They are divided into three main groups: (1) Resecting a piece of the muscle and re-attaching the tendon to the original insertion. (2) By tucking part of the muscle or re-arranging the fibres so that the muscle is shortened. (3) Advancement of the attachment. Each method is good if properly done and many surgeons have modified them to suit their invidual needs. Some are more difficult to do and give more reaction than others. An eye surgeon should learn to do one type of operation well and if good results are obtained that is all that is necessary. An operation should not be condemned just because it fails in the hands of one surgeon. I have developed a method of doing a resection by which I have obtained very good results. It seems to give more correction and overcomes some of the difficulties encountered in other types of operations. No claim of originality is made and apologies are offered if it may appear the same as another's original technique.

TECHNIQUE OF OPERATION FOR STRENGTHENING INTERNAL AND EXTERNAL RECTI

The conjunctiva is picked up about 10 mm. from the limbus and an incision about 7 mm. long made parallel to the limbus (Fig. 5A). Tenon's capsule is picked up below and an incision made through it. The muscle hook is introduced to pick up the muscle. No effort is made to freely dissect the muscle, as a better result is obtained if as little dissection as possible is done (Fig. 5B). The muscle clamp is applied and the muscle cut from its attachment leaving enough of the tendon on the sclera to secure the sutures (Fig. 6C). Two double arm 000 catgut sutures are put in the muscle from the outside surface to the inside, medial to the clamp. The exact position is determined by the amount of resection one desires (Fig. 6D). While the assistant holds the muscle clamp, the sutures are put through the muscle clamp, drawn up tightly and tied. The necessary pulling is done by the muscle clamp and not by the sutures, so there is no tendency for the sutures to split muscle fibres and pull along the length of the muscle. When the sutures are tied, the tight loop clamps the muscle fibres together, so that there is very little danger of post-operative movement causing the muscle to pull through the sutures (Fig. 6E). The cut fibres seem to adhere to the original stump even though they are not in exact apposition. The excess muscle is cut off, still in the clamp, and the conjunctiva is closed with interrupted sutures (Figs. 7F and 7G). The eye is bandaged for ten days. The reaction usually subsides in three or four weeks.

Good results have been obtained in cases of convergence weakness in which the patient could not converge at all. A resection of the internal rectus gave good convergence power. No bad effect has been observed in burying the catgut in the conjunctiva. Sometimes there is more reaction than with silk but if care is taken to soak the catgut in saline after it is removed from the capsule, it is easier to handle and the reaction it causes is less.

Many surgeons advocate delaying the operation until it can be done under local anæsthesia. I believe this to be absolutely wrong. If the surgeon has to determine how much he should do by the appearance of the eye while he is operating, he will be destined to many failures. The patient is usually under a sedative and the muscle action is partially paralyzed due to operative trauma and local anæsthetic. The amount and type of operation should be determined beforehand, and then, if necessary done under a general anæsthetic. Two hundred cases, including adults and children have been done under a general anæsthetic and the results have been consistently good, so that it is not necessary to put the patient through a very uncomfortable and sometimes nauseating procedure with a local anæsthetic.

CONCLUSIONS

(1) Proper diagnosis is most important in obtaining good results in the treatment of strabismus. (2) Too much emphasis cannot be placed on the importance of early treatment. No child should be allowed to go through school with crossed eyes. (3) If an operation is necessary it should be done before school age, and it is much easier under general anæsthesia. (4) The technique in detail is given for strengthening an ocular muscle. (5) No exact rules can be given for treatment or operative procedure. There is a great individual variation in cases of a similar type. As in all branches of surgery, good judgment and common sense are prerequisite.

REFERENCE

1. JAMIESON, P. C.: Surgical entity of muscle resection. *Arch. Ophth.*, 1931, 6: 329.